CARPENTER ANT (HYMENOPTERA: FORMICIDAE) TUNNELS VISUALIZED BY COMPUTED TOMOGRAPHY[1]

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ABSTRACT: Carpenter ant *(Camponotus* sp.) tunnels within a wooden beam of Douglas fir *(Pseudotsugo menziesii)* were studied by X-ray computed tomography. A pattern characterized by the main, or lead, tunnel within the pith and giving rise to an ever expanding set of tunnels was noted. This innovative method of examination of wood specimens provides accurate information about the interior tunnel systems of the ants without the need for sectioning the wood and destroying the specimen.

Carpenter ants, *Camponotus* sp., are common, economically important animals with a world wide distribution. Within the United States the nine most common species are found primarily in the heavily wooded moist northeast and northwest (Olkowski, Daar, and Olkowski, 1991). Most species seek protection within tunnels excavated in dead or decaying wood, but are capable of chewing through undamaged wood as well. They may be attracted to man made structures, particularly if the wood is weathered or if the structure contains small hollow areas within wooden walls (Olkowski, Daar, and Olkowski, 1991). Since they do not feed on the wood and since a colony may require 3-6 years to grow to its mature size of roughly 2000 individuals, they are often slow to cause extensive damage (Ebling, 1978).

The economic importance of carpenter ants derives primarily from their tunnel excavations, consequently tunnel structure has been extensively studied. It has long been known that they preferentially chew through the softer heart and spring wood to produce a pattern of ever enlarging concentric tunnels (Goetsch, 1953). in the past, making these observations has required the destruction of the wooden structure that holds the nest; this paper presents the results of an alternative method which uses X-ray computed tomography to map the 3-dimensional architecture of *Camponotus* tunnels without destroying the original specimen.

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MATERIALS AND METHODS

A severely damaged wood beam was obtained from the Field Museum of Natural History in Chicago, Illinois (Figures 1 & 2). The specimen was donated by a sculptor who had bought it for his work. Its origins prior to that are unknown. The wood was identified by vascular anatomy to be Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco. It measured 9cm X 8.5 cm X 63.5 cm.

The wood was scanned with a 1005 type head EMI computerized axial tomography (C.A.T.) scanner (EMItronics Inc., X-ray Systems Division, Northbrook, Illinois), an early generation computed tomography machine manufactured in the early 1970s. It is designed to obtain cross-sectional X-ray images of the human brain and to reconstruct them digitally. Each cross-sectional plane is scanned several times from a variety of angles over 240° while corresponding X-ray attenuation data are gathered. Since the degree of X-ray attenuation is dependent on the density of the object, the image is a computer reconstruction of the density of the material. In this study, an 8 mm thick x-ray beam was used for each slice, with a energy of 120 kV and 33mA.

RESULTS

A representative sample of the images is shown in Figures 3a-f. In these photographs white areas are wood of sufficient density that it can be resolved by the computer (usually summer wood). The dark areas are either empty spaces or wood of such low density (usually spring wood) that it cannot be resolved by the machine at the energy settings used. The leading end of the ant tunnels is seen in the pith of the beam in Figure 3a. This section corresponds to the right arrow in Figure 1. As one travels toward the outer end of wood beam (i.e., toward the end pictured in Figure 2), the extent of the tunnels becomes progressively enlarged (Figures 3a-3f). While the density of the spring wood was less than the resolution of the machine at the energy settings used, selective destruction of the spring wood can be ascertained by the clear presence of remnants of summer wood within the major portion of the tunnels (Figures 3c, 3d, and 3e).

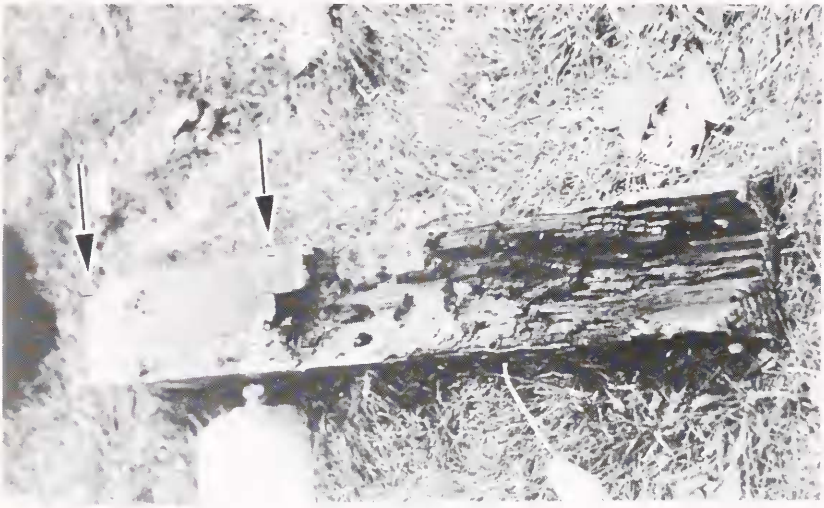

Figure 1. The Douglas fir specimen used in this study. Only the portion between the arrows was scanned. The right arrow corresponds to Figure 3a, while the left arrow corresponds to Figure 3f.

Figure 2. Typical macroscopic pattern of severe *Componotus* damage. This photo corresponds to Figure 3f.

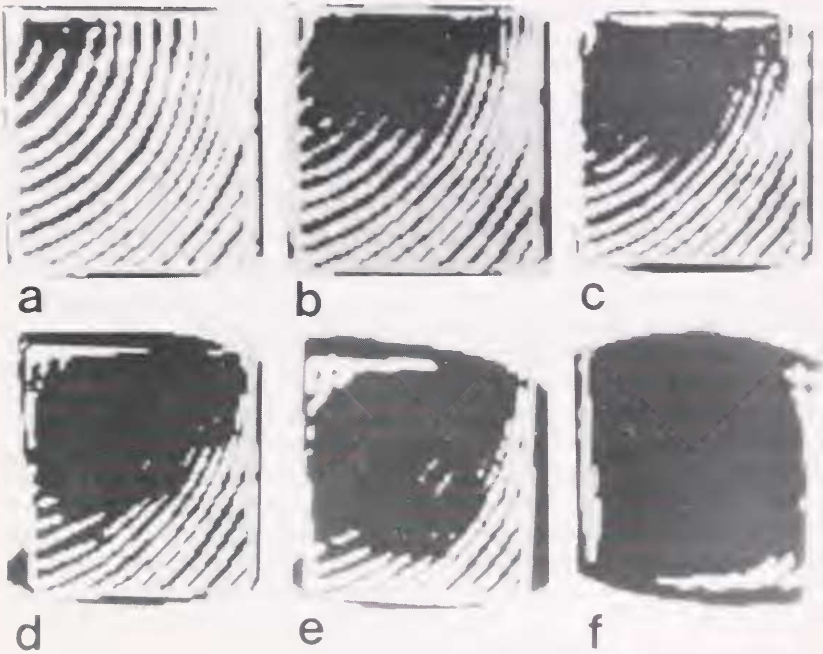

Figure 3. Six representative photographs from a total of 24 taken. Each image is the average density of 8 mm thick slice of wood. (a) The leading end of the tunnel. Note that the ants start at the soft pith. (b-e) A series revealing the progressive widening of the ant excavations. Remnants of denser spring wood can occasionally be seen within the main body of the tunnel. (e) At the outer edge of the tunnel, the entire thickness of the beam is damaged.

DISCUSSION

Computerized tomography is a medical diagnostic instrument that visualizes the internal soft tissue anatomy of the human body and brain (Huckman, 1975; Weisberg, 1979). Its use in clinical medicine is now quite extensive.

The application of this technique to the study of tunnels created by *Camponotus* is proposed, and our study verifies that the results obtained by this method are similar to previously reported patterns of tunnel architecture. Specifically, the X-ray data is compatible with the primary or leading end of carpenter ant tunnels being through the softer pith and with the ants expanding their tunnels laterally with some sparing of the denser summer wood (Goetsch, 1953).

However, there are various limitations to the technique. First, the great size and intricacy of the machine prevent any level of portability. This reduces the potential application of this technique to relatively small specimens that must be brought to the instrument. Second, at current prices, computerized tomography time is very expensive (human diagnostic charges average $600.00 per hour, and one hour would be needed for most specimens). Third, while overall tunnel structure can be visualized, small structural details, or the insects themselves are below the level of resolution. The thickness of the X-ray beam, 8 mm in the model used in this study, and software limitations of this and more advanced models, make maximal resolution approximately 5 mm. Finally, in this study full appreciation of the tunnel system was limited due to inability to visualize the less dense spring wood. This problem can be partly alleviated by decreasing the energy of the X-ray beam, and is not a problem when scanning more dense material.

Nonetheless, this technique may be useful for ascertaining the extent of insect damage to valuable wooden specimens (e.g., sculptures, antiques, etc.). More importantly, since 3-dimensional reconstructions can be made from the digitalized data, additional perfection of this technique can lead to the creation of manipulatable perspective images that can be used for teaching or comparing 3-dimensional nest structure of various species.

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LITERATURE CITED

Ebeling, W. 1978. Urban Entomology. Univ. of Calif. Press, Berkeley, CA, 695 pp.

Goetsch, W. 1953. The Ants. The Univ. of Mich. Press, Ann Arbor, MI, pp. 52-58.

Huckman, M.S. 1975. Clinical experience with the intravenous infusion of iodinated contrast material as an adjunct to computed tomography. Surgical Neurology 4: 297-318.

Olkowski, W., Daar, S., and Olkowski, H. 1991. Common-Sense Pest Control. Taunton Press, Newton, CT, 715 pp.

Weisberg, L.A. 1979. Computed tomography in the diagnosis of intracranial disease. Annals of Internal Medicine 91: 87-105.